Scope in an incremental context

Lecture 3: Psycholinguistic aspects of scope interpretation

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Part 1: methods of investigation

I got the impression that some of the audience does not have a psycholinguistic background. . .

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What follows is a very non-technical "crash course" in what some experimental psycholinguists do.

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The central issue is thus: the "time course" of an utterance in the processing system.

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- Introspective - conscious human report, judgements, linguistic responses etc.
- Reaction-based - observed behavioural changes, time delays, etc., in response to stimulus.
- Physiological - some measurable aspect of the body (usu. brain) that reflects some biological "effort".

Introspective measurement

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- Pro: often very fast/cheap to collect, *often does* lead to good insights, scientifically strong results.
- Con: not "real-time" and prone to dangers of subjectivity.

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- Pro: remove some amount of subjectivity, often fine-grained (ms-scale) rich data.
- Con: somewhat expensive equipment, very indirect, very sensitive to experimental conditions.

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Measurement of signals from the body at varying degrees of depth. E.g.:

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How this might work:

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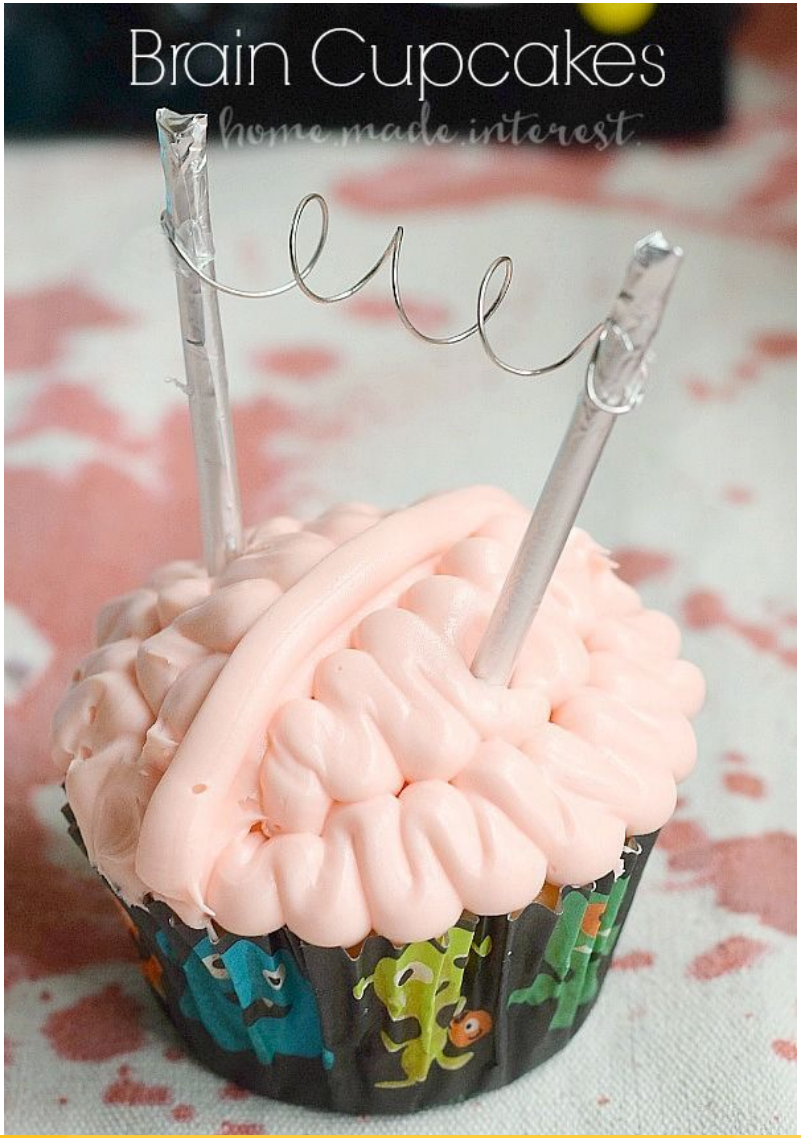
- Pro: somewhat more direct view of *something* happening in the brain.
- Con: very expensive equipment and software, sometimes limited time or spatial resolution.

Things psycholinguists like



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*For values of validation that include, "do you trust their way of calculating a p-value?"

Part 2: context-continuation

Quantifier scope ambiguity

Everybody loves somebody.

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But seriously. . .

. . . a lot of effort went into static, structural explanations of quantifier scope ambiguity, either at the syntactic or the semantic level or both. e.g.:

- Quantifier raising (movement theory, yeah :)).
- Type-raising theories.
- Cooper storage.
- Combinations and variations thereof. . .

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Problem: exactly how to verify this in behaviour.

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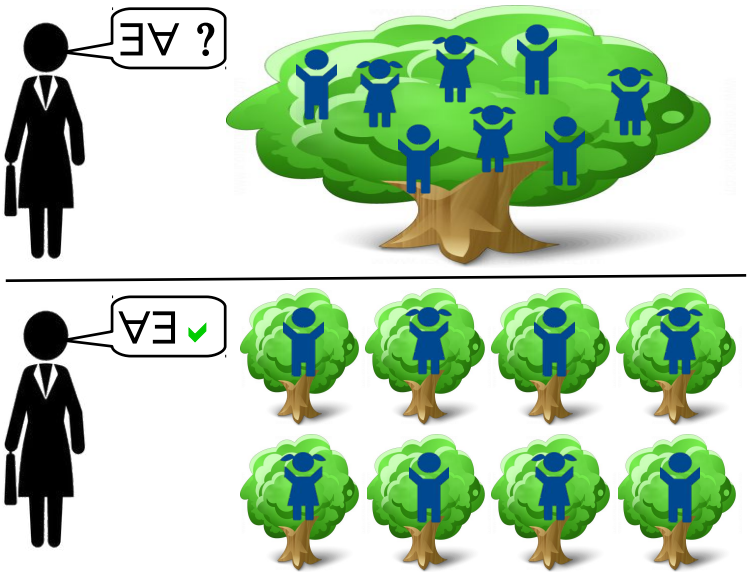

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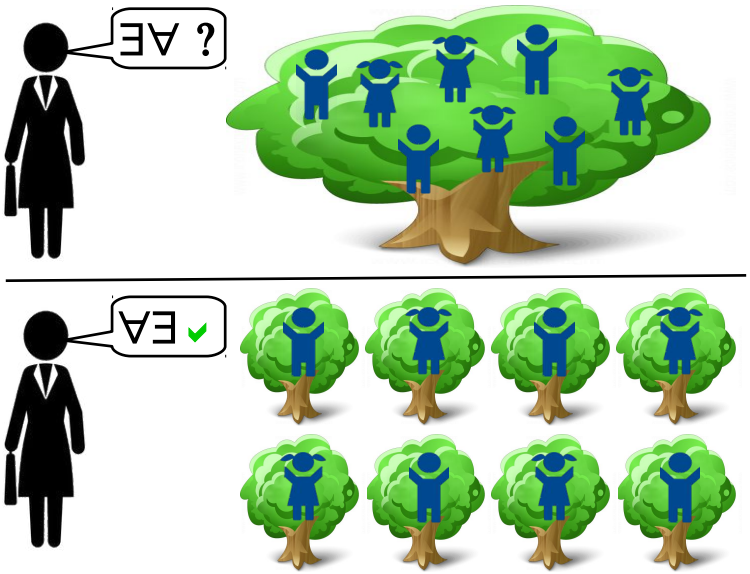

Perhaps we can use the creation of expectations about set cardinality to investigate what is "really going on".

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"Default" hypothesis: some combination of all three?

Two-quantifier experiments

Kurtzman and Macdonald [1993]: Context-continuation judgement paradigm.

Table 1. *Example stimuli, Experiment 1*

Sentence	Ambiguous, WS1	Ambiguous, WS2	Unambiguous, WS1	Unambiguous, WS2
"Every . . . a" quantifier order				
Quantifier	Every kid climbed a tree.	Every kid climbed a tree.	Every kid climbed a different tree.	Every kid climbed the same tree.
Continuation	The trees were full of apples.	The tree was full of apples.	The trees were full of apples.	The tree was full of apples.
"A . . . every" quantifier order				
Quantifier	A kid climbed every tree.	A kid climbed every tree.	The same kid climbed every tree.	A different kid climbed every tree.
Continuation	The kid was full of energy.	The kids were full of energy.	The kid was full of energy.	The kids were full of energy.

Experiment 1: subjects judge whether the continuation is compatible with the context.

Two-quantifier experiments

Kurtzman and Macdonald [1993]: results

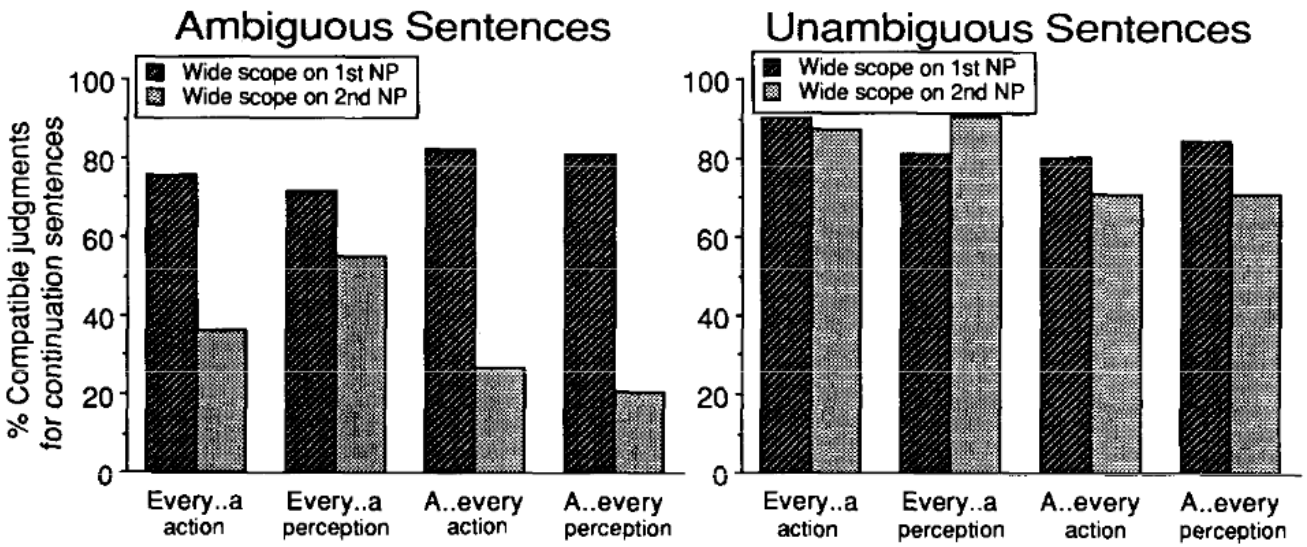

Figure 1. *Compatibility judgments for continuation sentences in Experiment 1.*

Main upshot of experiment 1: linear order strongly preferred.
(Later experiments find otherwise for complex NPs.)

Part 3: heuristic accounts

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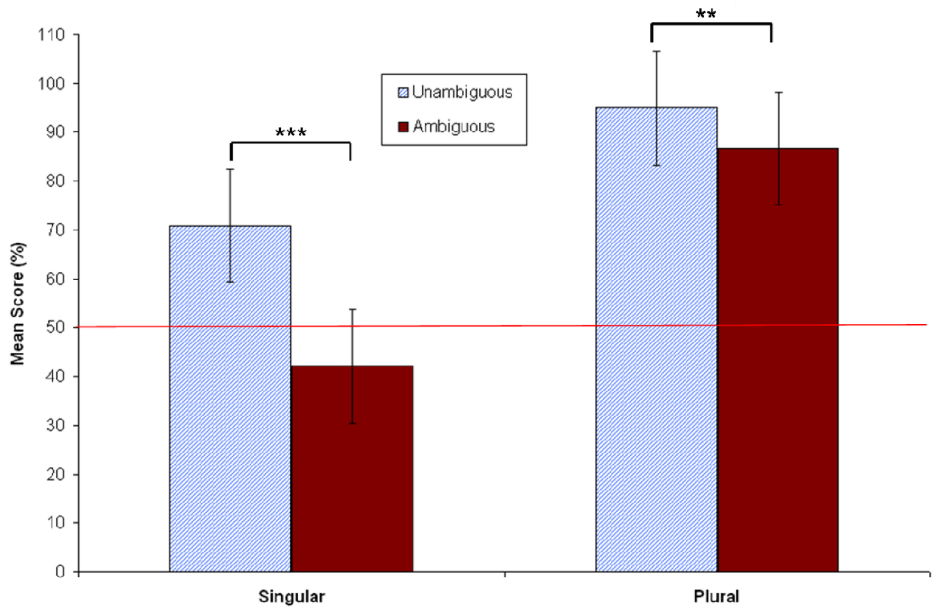

Subjects really bad at singular case!

Two-quantifier experiments

Readings for: Every child climbed a tree.

- For each child, that child found a tree and climbed it.
  Linear scope
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English speakers prefer the linear reading much more strongly than the inverse readings **even when strongly prompted otherwise**. (Dwivedi, 2013)

Two-quantifier experiments

Readings for: Every jeweller examined a diamond.

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English speakers prefer the linear reading much more strongly than the inverse reading **but not as strongly as with the "children-tree" example**. (Dwivedi, 2013)

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  - At continuation sentence, you can't entirely distinguish reanalysis from violation of world knowledge expectation
- **Problem**: word order. Maybe English-speakers don't expect to have to deal with order change.

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Can't use Kurtzman and Macdonald stimuli to test this in English.

Quantification with ditransitives

Paterson et al. [2004]: eye-tracking study experimental conditions

Table 1
Predictions Concerning Reading Time Effects for Plural (Pl) and Singular (S) Noun Phrases at the NP Anaphor Region, Including Examples of DO-First and IO-First Sentences Used in the Experiment

Condition		Linear Order Principle	Grammatical Hierarchy Principle	Quantifier Hierarchy Principle
A	DO-first / *a–every* The celebrity gave$_1$| an in depth interview to every reporter from the newspaper, but$_2$| the interview(s) was/were$_3$| not very$_4$| interesting.$_5$	S < Pl	Pl < S	Pl < S
B	DO-first / *every–a* The celebrity gave$_1$| every in depth interview to a reporter from the newspaper, but$_2$| the reporter(s) was/were$_3$| not very$_4$| interested.$_5$	Pl < S	S < Pl	Pl < S
C	IO-first / *a–every* The celebrity gave$_1$| a reporter from the newspaper every in depth interview, but$_2$| the reporter(s) was/were$_3$| not very$_4$| interested.$_5$	S < Pl	S < Pl	Pl < S
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Predictions concerning reading time effects for the doubly quantified region:

Ioup (1975) Grammatical hierarchy × quantifier hierarchy	'every interview . . . to a reporter' > 'an interview. . . to every reporter' 'a reporter . . . every interview' > 'every reporter . . . an interview'
Fodor (1982) Linear order × quantifier characteristics	'an interview. . . to every reporter' > 'every interview . . . to a reporter' 'a reporter . . . every interview' > 'every reporter . . . an interview'

Note—Vertical lines delimit analysis regions, and slashes denote alternatives.

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Table 3
Mean First-Pass and Total Reading Times (in Milliseconds) for Regions 2–4, Second-Pass Reading Times for Region 2, and Residual First-Pass and Total Reading Times for Region 3 of *a–every* and *every–a* DO-First and IO-First Sentences With Singular and Plural Continuations

		a–every				*every–a*			
		Singular		Plural		Singular		Plural	
Region	Measure	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
DO-first									
2	First-pass time	1,931	452.2	1,787	518.0	2,011	569.7	2,059	545.4
	Second-pass time	599	665.6	755	835.2	789	827.9	699	869.0
	Total time	2,530	755.1	2,541	968.9	2,800	975.4	2,759	973.3
3	First-pass time	394	110.7	455	157.7	361	93.8	415	131.3
	Residual first-pass time	−194	100.1	−145	121.0	−231	95.7	−194	99.3
	Total time	512	204.3	605	360.2	514	221.8	593	292.2
	Residual total time	−272	160.9	−173	190.5	−270	154.3	−202	148.2
4	First-pass time	299	78.2	285	66.7	307	74.7	297	73.6
	Total time	451	155.0	431	124.8	450	118.0	465	154.9
IO-first									
2	First-pass time	1,840	474.5	1,867	555.2	1,794	438.8	1,747	516.4
	Second-pass time	998	1,172.3	1,093	1,002.2	630	702.1	689	816.3
	Total time	2,839	1,271.2	2,960	1,112.1	2,424	919.3	2,436	935.5
3	First-pass time	368	102.0	406	120.1	357	93.7	453	126.2
	Residual first-pass time	−220	78.1	−191	95.0	−232	108.7	−146	99.3
	Total time	552	369.8	625	269.8	499	248.0	621	336.7
	Residual total time	−217	201.7	−152	184.8	−286	149.5	−165	174.7
4	First-pass time	283	70.8	294	61.6	313	91.5	299	71.4
	Total time	465	180.9	446	131.5	481	172.1	459	134.6

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- "a-every" total reading times longer: linear order interacts with quantifier hierarchy.

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  - Interaction between quantifier and gramm. hierarchies: based on a theory that DO is "higher" than IO.
- "a-every" total reading times longer: linear order interacts with quantifier hierarchy.

Possible problem: DO/IO syntax in English rather complicated!

Part 4: higher-order specification

Scope ambiguity in processing

Consider the following sentence and continuations [Dotlačil and Brasoveanu 2015]:

(1) A caregiver comforted a child every night.

   a. The caregiver wanted the child to get some rest.
   b. The caregivers wanted the child to get some rest.
   c. The caregiver wanted the children to get some rest.
   d. The caregivers wanted the children to get some rest.

There are four plausible readings of the first sentence, based on the scope of "every night".

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With three quantifiers: can investigate whether there is a preferred specified order in incremental context.

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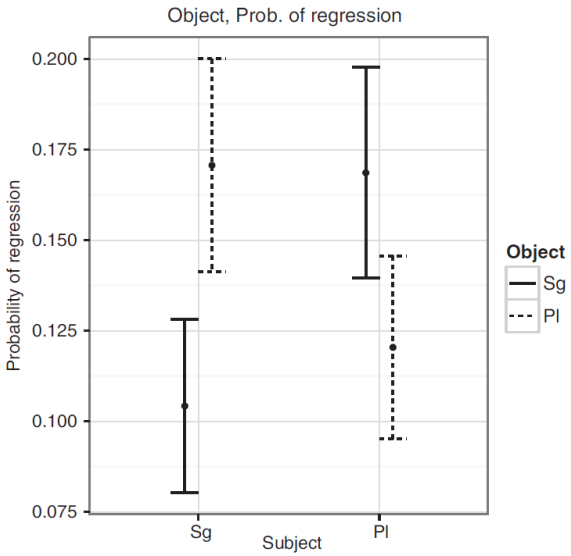

Scope ambiguity in processing

(2) A caregiver comforted a child every night.

- The linear order is $\exists = \exists > \forall$, ie, child and caregiver singular.
- English speakers can be easily prompted to all other orders.
- Dotlačil and Brasoveanu (2015):

The caregiver wanted the child to get some rest.
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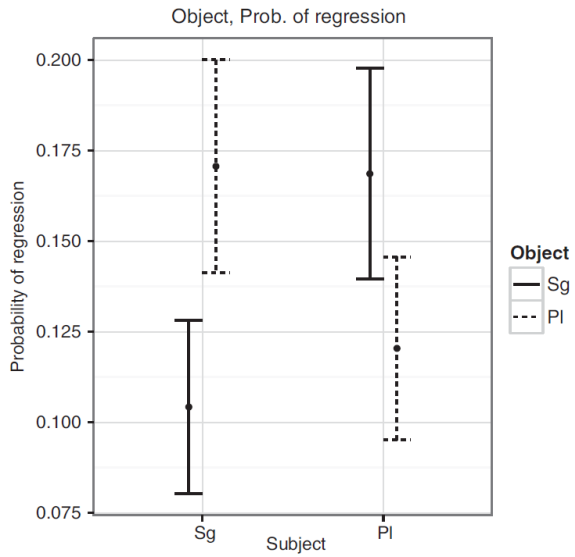

Evidence for algorithmic processing (as opposed to purely pragmatic considerations).

Focus on role of world knowledge

Judgement study [Sayeed, Lindemann, and Demberg, 2019]:

- Exploit non-English linguistic phenomena; for example, German verb-second.

(3) a. Jeder Spion hat diesen/einen/diese Auftrag/Aufträge erhalten. Der/die Auftrag/Aufträge
Every spy-NOM has this/a/these order(s)-ACC received. The order(s)
war(en) gefährlich und riskant.
was/were dangerous and risky.
'Every spy received this/a/these order(s). The order(s) was/were dangerous and risky.'

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Manipulate word order in Dwivedi-style experiment to test whether world knowledge truly dominates linear/inverse distinction.

First step: judgement study

24 stimuli in either German word order (unscrambled vs. scrambled):

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- Native speaker assists in judging plurality of response.

Experimental goals

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For indefinite article: plural bias of existentially quantified noun should be higher in unscrambled than in scrambled sentences.

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- If effect observed, surface order competes with world knowledge bias of plurality.
- If plural bias still present, even if effect holds, world-knowledge bias must overcome word order.
  - Evidence for interaction between world knowledge and reanalysis process.

Results and analysis

Result from logistic mixed-effects modeling of judgements we collected:

- Significant main effect of surface order for indefinite condition ($b = 0.93$, $p = 0.001$, $z = 3.26$) such that SVO order results more often in a plural response.

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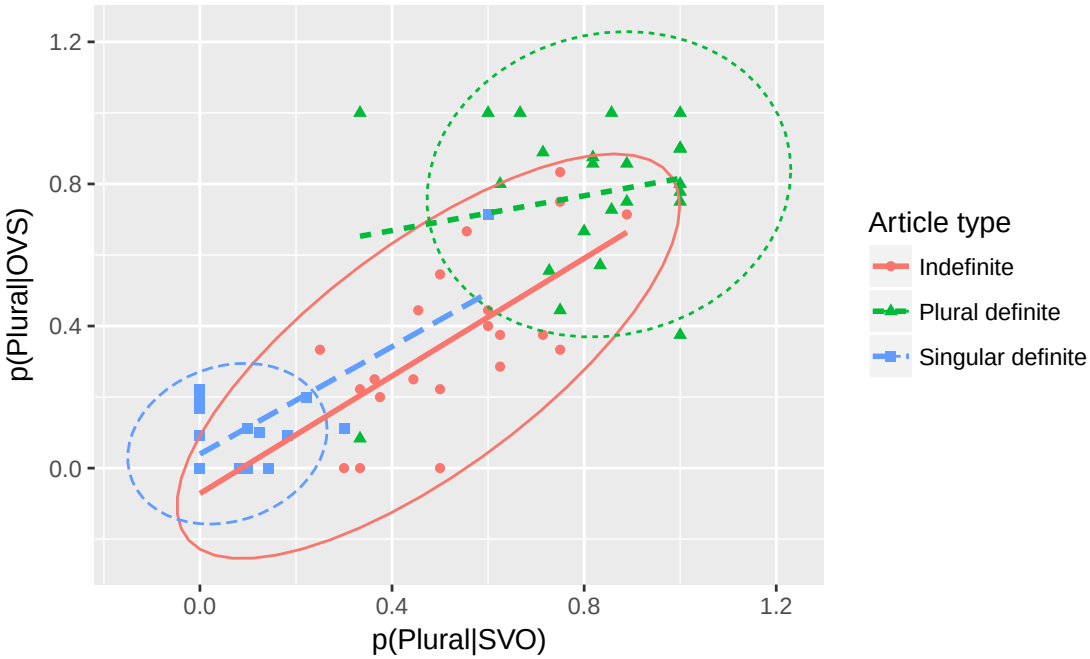
- Significant main effect of surface order for indefinite condition ($b = 0.93$, $p = 0.001$, $z = 3.26$) such that SVO order results more often in a plural response.
- Plurality correlation between OVS vs. SVO order strong for indefinite articles.



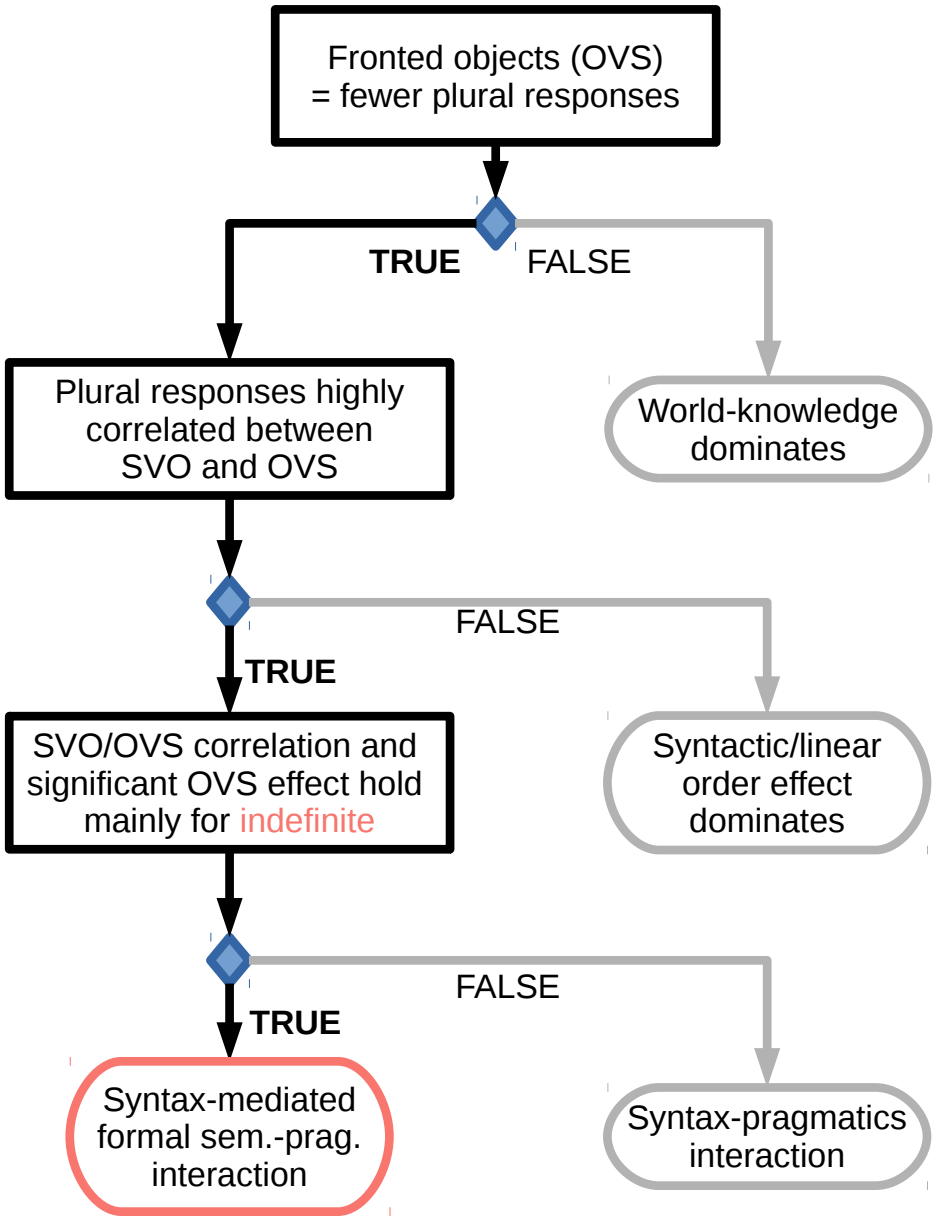
Results and analysis

Binomial logit model in `glmer` over indefinite article condition:
$Plurality \sim Linearity + (1|Item) + (1 + Linearity|Subject)$

	b	Std. Error	z	$Pr(>\|z\|)$	
Intercept	-1.1176	0.3732	-2.994	0.00275	**
Linearity(unscrambled)	0.9260	0.2844	3.256	0.00113	**

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Hypothesis space



Tomorrow: matters computational; representing experimental results